PB82-181819

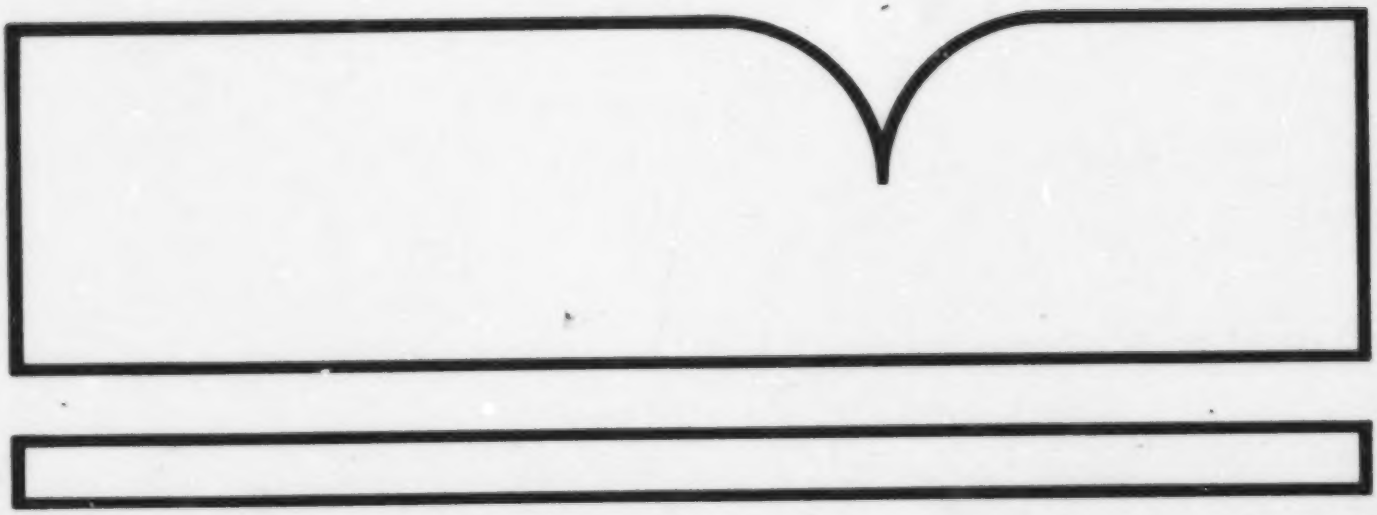
Continuous Monitoring for Sulfur Dioxide at a Utility Boiler Equipped with a Limestone Scrubber

Research Triangle Inst.
Research Triangle Park, NC

Prepared for

Industrial Environmental Research Lab.
Research Triangle Park, NC

Feb 81



U.S. Department of Commerce
National Technical Information Service
NTIS

IERL-RTP-P-354

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

PB82-181819

1. REPORT NO. EPA-600/J-81-535	2. Journal Article
3. RECIPIENT'S ACCESSION NO.	
4. TITLE AND SUBTITLE: Continuous Monitoring for Sulfur Dioxide at a Utility Boiler Equipped with a Limestone Scrubber	5. REPORT DATE: March 1982
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S): E. F. Peduto and R. B. Strong (RTI), and W. B. Kuykendal (EPA/IERL-RTP)	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Research Triangle Institute, P.O. Box 12194, Research Triangle Park, North Carolina 27709	10. PROGRAM ELEMENT NO. 1NE828
	11. CONTRACT/GRANT NO. 68-02-2156
12. SPONSORING AGENCY NAME AND ADDRESS: EPA, Office of Research and Development, Industrial Environmental Research Laboratory, Research Triangle Park, NC 27711	13. TYPE OF REPORT AND PERIOD COVERED: Journal article; 1-2/79
	14. SPONSORING AGENCY CODE: EPA/600/13

15. SUPPLEMENTARY NOTES: Published in the Journal of the Air Pollution Control Association Vol. 31, No. 2, pp. 192-196, February 1981.

16. ABSTRACT: The paper gives results of a 30-day SO2 monitoring program conducted at a utility boiler equipped with a limestone scrubber. Program objectives were: to demonstrate the reliable use of continuous monitoring equipment for determining scrubber performance, and to support the proposed revised New Source Performance Standards (NSPS) published in the September 19, 1978, Federal Register. Generally, continuous monitoring equipment is reliable as a source surveillance method. Results of the data collected indicate that the test site monitored is capable of performing under the guidelines of the proposed revised NSPS.

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution Continuous Sampling Monitors Measurement Sulfur Dioxide Boilers Utilities Scrubbers Calcium Carbonates	Pollution Control Stationary Sources	13B 14B 07A,13I 14G 07B 13A

18. DISTRIBUTION STATEMENT: Release to Public	19. SECURITY CLASS (This Report): Unclassified	21. NO. OF PAGES: 5
	20. SECURITY CLASS (This page): Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

EPA-600/J-81-535
Journal Article

Reprinted from **APCA JOURNAL**, *Vol. 31, No. 2, February 1981*

Continuous Monitoring for Sulfur Dioxide at A Utility Boiler Equipped with a Limestone Scrubber

E. F. Peduto
GCA Corporation
GCA/Technology Division

R. B. Strong
Research Triangle Institute

W. B. Kuykendal
U.S. Environmental Protection Agency
Industrial Environmental Research Laboratory

The results of a 30-day sulfur dioxide monitoring program conducted at a utility boiler equipped with a limestone scrubber are presented. Program objectives were twofold: to demonstrate the reliable use of continuous monitoring equipment for determining scrubber performance and to support the proposed New Source Performance Standards (NSPS) published in the September 19, 1978, *Federal Register*. In general, continuous monitoring equipment is reliable as a source surveillance method. Results of the data collected indicate that the test site monitored was capable of performing under the guidelines of the proposed NSPS, and were incorporated in the final NSPS promulgated on June 11, 1979.

Due to the oil embargo and the spot shortages of natural gas for home heating during the winter months, there has been a shift in the national energy policy from encouraging the use of clean fuels, such as fuel oil, natural gas, and low-sulfur western coal, to encourage the use of local eastern coal in conjunction with applicable control equipment.[1] It has been shown that the utilization of local coals with applicable control equipment is more economical than the use of low-sulfur western coal with limited control equipment. This is due largely to the cost of transporting western coal to central and eastern states. Also, the increased fuel usage associated with the transportation of western coal is a deterrent to energy conservation.

In the September 19, 1978, *Federal Register*,[2] the Environmental Protection Agency proposed a set of revised New Source Performance Standards (NSPS) and a candidate continuous reference method for determining compliance with the proposed revised NSPS which were later promulgated and published in the June 11, 1979 *Federal Register*.[3] The proposed revised NSPS addressed sulfur dioxide, total oxides of nitrogen, and particulate emission limits, and the application of the best available technology for maintaining compliance with the proposed revised NSPS. Briefly, the proposed NSPS for sulfur dioxide would require that the control device remove at least 85% of the SO_2 from boiler gases (based on a 24-hr average), except that for 3 days out of each 30-day period a removal efficiency of 75% would be permitted. These standards were to apply to newly built, modified, or reconstructed utility boilers capable of combusting greater than 73 MW of fossil fuel. The revised NSPS published in the June 11, 1979, *Federal Register* specified a revised SO_2 requirement and appeared as follows: "A source operator must demonstrate a 90 percent sulfur dioxide reduction based on a 30-day *rolling* average."

From January 1, 1979 through February 21, 1979, the Research Triangle Institute (RTI), under contract to the EPA, conducted a monitoring program to collect 30 days of continuous data at a coal-fired power plant. Sulfur dioxide and oxygen concentrations were monitored concurrently at the inlet and outlet of a limestone scrubber module. Program objectives were twofold in nature. The project was designed to collect 30 days of data to predict whether the proposed NSPS for SO_2 can readily be attained and to demonstrate the use of Method 19 for verifying compliance with the proposed NSPS. The program schedule was as follows:

- January 1–15, 1979: Monitoring system setup, check out, comparability checks against reference methods, etc.
- January 16–23, 1979: 168-hr conditioning period.
- January 23–29, 1979: Operational test period.
- January 16–February 21, 1979: Data collection phase.

From January 16 through February 21, 30 days of continuous data were collected. Seven days of downtime were experienced, three of which were attributable to plant outage and the remainder to monitoring system failure. Downtime attributable to monitoring system failure was due to pumping system failure and not to analyzer malfunction.

Test Site[4]

The test program was conducted at a utility coal-fired boiler equipped with limestone scrubber modules. Low-sulfur coal

with a heating value of 1.32 J/kg (10,000 Btu/lb), a sulfur content of 0.5%, and an ash content of 9.8% is the fuel source. Under full load conditions, the unit is capable of producing 125 MW of power.

Monitoring probes were placed at points in the duct work immediately before and after the south side scrubber module of Unit No. 4. Each probe was inserted into a port located at the center of the duct. The inlet port was located approximately 15 meters prior to the entrance of the rod scrubber and the outlet port was immediately following the gas reheater.

System Description

The monitoring system consisted of an extraction/conditioning module and a mobile laboratory that housed the analytical system. Thermo Electron Model 40 pulsed fluorescence analyzers were used to monitor SO_2 concentrations at both the inlet and outlet of the scrubber module. A Beckman Model 742 polarographic analyzer was used to monitor the inlet oxygen concentration and the outlet oxygen concentration was monitored by an MSA Model 802 paramagnetic analyzer.

Figure 1 contains a schematic diagram of the analytical system. Briefly, the system consisted of a heated probe with a 1.92-cm (¾-in.) nozzle oriented countercurrent to the gas flow to prevent the sampling of large particulate, a heated filter box/pump box assembly, a refrigeration cooler, and a distribution panel that readily enabled the sampling of calibration or sample gases. All connecting lines from the probe to the refrigeration cooler located in the mobile laboratory consisted of a 1.2-cm (½-in.) O.D. Teflon heat-traced line. After the cooler, 0.64-cm (¼-in.) O.D. Teflon tubing was used. Approximately 90% of the heated sample stream from the duct was vented at the mobile laboratory just prior to the cooler inlet by use of a 0–1.05 kg/cm^2 (0–15 psig) back-pressure regulator, as shown in Figure 1. This ensured that a constant pressure was maintained from the pressure side of the pump to the sample distribution panel located in the mobile laboratory.

The extraction/conditioning system also contained a blowback purge system designed to purge the filter module and probe of particulates. This system was manually activated for approximately 30 seconds each morning and night.

Data were acquired using an Acurex Auto Data Nine system with a 24-channel Esterline Angus multipoint recorder as a backup in case of Auto Data Nine failure. Instantaneous millivolt values were recorded every 5 min by the Auto Data Nine.

System Operation/Probe Positioning

The extraction system was operated at a constant flow rate of approximately 43 stdL/min (1.55 stdft^3/min) with a constant back pressure of 0.35 kg/cm^2 (5 psig). All heat-traced lines and heated boxes were operated at temperatures ranging from 130° to 200°C. Sample flows to the oxygen analyzers were maintained at 45 stdL/hr (1.65 stdft^3/hr). The sulfur dioxide analyzers contained individual sampling pumps for controlling the analyzer sample flow.

All analyzers were calibrated daily at approximately 0900 Central Standard Time with span concentrations corresponding to at least 0, 50, and 90% of the operating range. Data were collected instantaneously at 5 min intervals by the Auto Data Nine. Data printouts also contained secondary parameters such as line, cooler, probe, filter, and pump temperatures.

The individual analyzers were operated in the ranges shown in Table I and calibrated with the types of standards listed. The calibration standards were verified according to the procedures in Performance Specifications 2 and 3.[2] Standards for calibrating the SO_2 analyzers consisted of compressed gas cylinders containing SO_2/air. The SO_2 inlet analyzer was

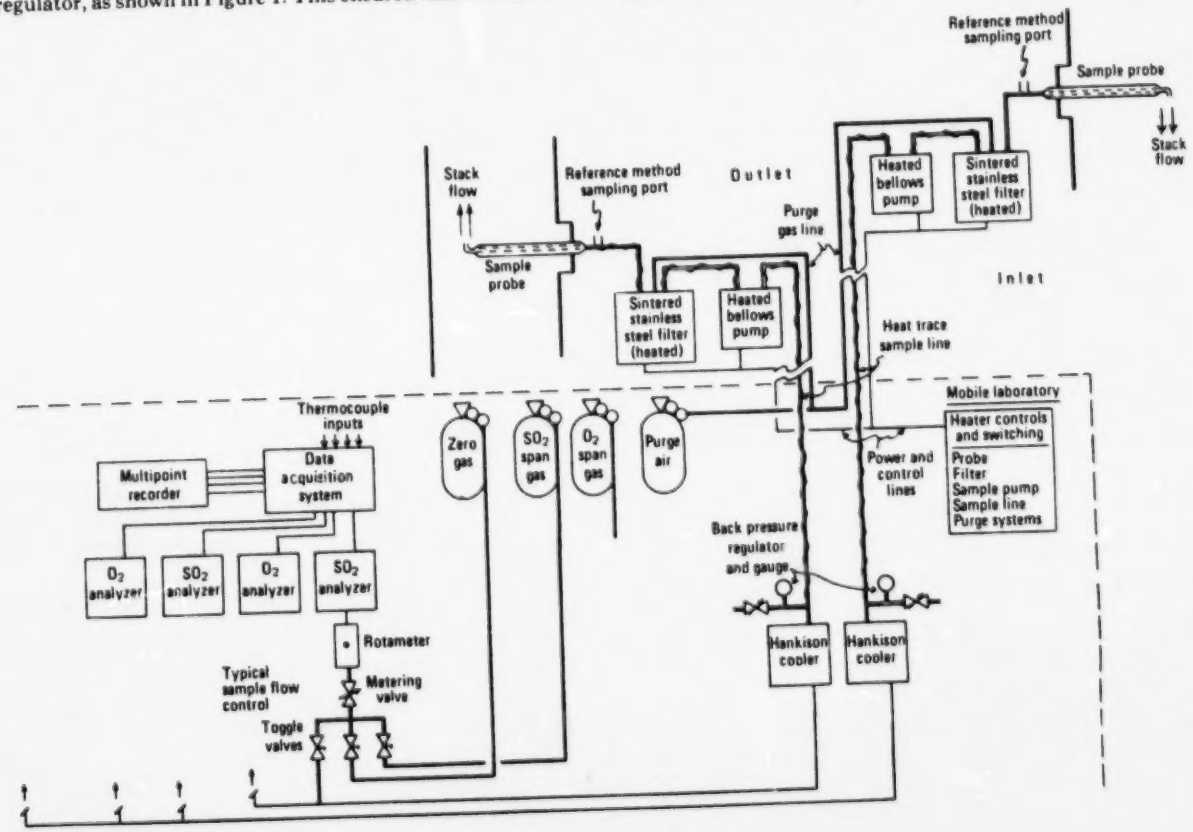


Figure 1. Monitoring system schematic.

Table I. Analyzer specifications.

Analyzer	Location	Range	Calibration standard
TECO Model 40	Inlet	0–1000 ppm	SO_2/air
TECO Model 40	Outlet	0–100 ppm	SO_2/air
Beckman Model 742	Inlet	0–10%	O_2/N_2
MSA Paramagnetic Analyzer	Outlet	0–10%	O_2/N_2

calibrated daily with nominal concentrations of 0, 80, 360, and 811 ppm standards. The O_2 analyzers were calibrated using 0, 4.7, and 8.1% oxygen in nitrogen cylinders. All cylinder concentrations were verified in triplicate on two occasions using the applicable EPA reference method: i.e., Method 6 for SO_2 and 3 for O_2.

Prior to the initiation of the data collection phase, a stratification check was performed. Single-path gas concentration profiles were developed for the inlet and outlet sampling sites by traversing through existing ports (one for each site) across the ducts at seven different positions for 5 min at each position. The millivolt responses of the sulfur dioxide and oxygen analyzers were recorded at the end of each traverse point. At the conclusion of this test, the probe was placed at a point of average concentration.

Discussion of Results

Span Gas Verification

The verification results for the span gas cylinders are contained in Tables II and III. All cylinders were analyzed on two occasions in order to satisfy the requirements that the analyses be within 2 weeks of the operational test period.

All analyzers were zeroed using grade 4 nitrogen from Airco (99.995% pure). This gas was not analyzed because its purity specifications (as stated by the manufacturer) exceeded those required for a zero gas.

An NBS-SRM (942 ppm SO_2/N_2) cylinder was analyzed as a control standard during the first analytical period (12/3/78) to demonstrate the accuracy of the cylinder verification results. As is noted in Table II, the difference between the analyzed values and the accepted value is 6 ppm or −0.64%.

Stratification Check

Tables IV and V contain the results for the respective stratification checks for each sampling port. The almost constant response across the duct indicates that stratification is not a problem at either of the sampling locations.

Table II. Span gas verification results for SO_2.

Date	Cyl. No. CC 13151 (ppm)	Cyl. No. CC 13085 (ppm)	Cyl. No. CC 13148 (ppm)	Cyl. No. CC 5985 (ppm)	Cyl. No. NBS 942 (ppm)
12/3/78	32.2	80.1	363	799	936
	32.7	81.0	358	819	
	31.9	80.6	361	816	
	33.7				
	33.1				
1/27/79	32.2	80.1	387	804	
	33.0	80.2	361	826	
	31.8	79.6	359	843	
Average Conc.	32.6 ± 0.7	80.3 ± 0.5	365 ± 11	818 ± 16	936
Manf. Conc.	40.0	72.0	400	900	942

Because no stratification was indicated, at the conclusion of this exercise the probes were placed toward the centroidal area of average concentration with the probe nozzle oriented countercurrent to the gas flow to prevent the sampling of large particulates.

The Operational Test Period

The operational test period was conducted January 16 through 29, 1979. All tests were performed according to revised Performance Specifications 2 and 3, which have been published in the *Federal Register*.[2]

The results of the operational test period are contained in Table VI. Results for the inlet SO_2 analyzer show acceptable performance in all categories while those for the inlet O_2 show that the analyzer did not satisfy the performance criteria for the midscale calibration error test (5% limit) and the 24-hr calibration drift test (0.50% O_2 limit). The two outlet analyzers did not satisfy performance criteria in two categories each: the SO_2 analyzer exceeded the performance criteria for the complete calibration error test and for the 24-hr calibration drift test while the outlet O_2 analyzer exhibited marginal performance for the midscale calibration error and 24-hr calibration drift categories.

Table III. Span gas verification for O_2.

Date	Cyl. No. CC 13033 (% O_2)	Cyl. No. CC 13053 (% O_2)
12/30/78	4.70	8.10
	4.60	8.00
	4.80	8.20
1/22/79	4.50	8.00
	4.60	8.10
	4.70	8.00
Average Conc.	4.65 ± 0.10%	8.07 ± 0.08%
Manf. Conc.	4.07%	8.50%

Table IV. Inlet results of the sampling site profile.

Point No.	Distance into duct m (ft)	Average SO_2 mV	Average O_2 mV
1	2.14 (7)	60.9	78.4
2	2.44 (8)	61.2	78.5
3	2.75 (9)	61.2	78.6
4	3.05(10)	60.8	80.8
5	2.14 (7)	60.5	79.6
6	1.83 (6)	60.6	78.7
7	1.53 (5)	60.8	78.7
Average		60.9	79.0
Standard deviation		0.3	0.8

Data Collection

Thirty days of data were collected from January 16, 1979, through February 21, 1979, according to the proposed continuous method[3] (Method 19). Seven days of data loss were experienced, as shown in Table VII. Three days were attributable to scrubber outage and the remaining 4 days were a result of monitoring system failure. On each occasion, the extraction conditioning section of the monitoring system malfunctioned causing data loss.

Table VII contains a summary of the thirty 24-hr averages obtained during the monitoring period. The average megawatt values designated with an (a) indicate that both parallel

Table V. Outlet results of the sampling site profile.

Point No.	Distance into duct m (ft)	Average SO_2 mV	Average O_2 mV
1	0.61 (2.0)	67.3	67.2
2	2.59 (8.5)	66.6	66.7
3	2.29 (7.5)	68.8	66.6
4	1.98 (6.5)	68.3	65.1
5	1.68 (5.5)	67.8	65.2
6	1.37 (4.5)	67.6	65.9
7	1.07 (3.5)	68.0	65.7
Average		67.8	66.1
Standard deviation		0.7	0.8

scrubber modules were in operation. This means that the boiler effluent stream was split between the two modules. Those values not designated by an (a) indicate that the full boiler effluent was passed through one scrubber module. During the period of January 16 through 23, 1979, the north scrubber module was inoperative and the full boiler effluent was passed through the south scrubber module where monitoring was taking place. The results indicate that at varying boiler loadings the scrubbing efficiencies were typically above 85%.

Table VI. Summary of results for the operational test period.

	Inlet		Outlet	
	SO_2 (% F.S.)	O_2 (% O_2)	SO_2 (% F.S.)	O_2 (% O_2)
Midscale calibration error	4.38	7.87 % F.S.[a]	10.7[a]	5.78 % F. S.[a]
Full-scale calibration error	1.35	3.37 % F.S.	6.40[a]	3.04 % F.S.
Relative accuracy	10.8		4.50	
24-hr zero drift	0.31	0.14	1.14	0.07
24-hr calibration drift	1.51	0.55[a]	3.48[a]	0.59[a]
2-hr zero drift	0.34	0.06	0.71	0.02
2-hr calibration drift	1.04	0.13	0.60	0.05
Response time	5.04 min	2.37 min	2.16 min	1.75 min

[a] Exceeds performance criteria.

Table VIII shows the relationship between the removal efficiency and the frequency of obtaining an efficiency in a certain range. It appears from this data set that the removal efficiency will typically be above the 85 percent proposed lower limit.

The data set obtained in Table VII has been submitted by EPA's Industrial Environmental Research Laboratory and analyzed by EPA's Office of Air Quality Planning and Standards and has been used to support the final NSPS published in the June 11, 1979, *Federal Register*.[3]

Conclusions

The results of the program were favorable with regard to the initial objectives. As previously stated, the objectives were to demonstrate the use of Method 19 as a continuous compliance check on power plant emissions and to obtain data to support the proposed NSPS. Method 19 was found to be satisfactory as a useful and reliable monitoring method. The equipment utilized remained operational greater than 90% of the time.

The data were analyzed by OAQPS and were judged to be satisfactory for support of the NSPS.

References

1. U.S. Environmental Protection Agency, *Federal Register* 44 (95): 28591-28591 (May 15, 1979).

Table VII. Summary of Monitoring Results.

Date	Inlet E 24-hr avg. ng/J	Outlet E 24-hr avg. ng/J	Average removal efficiency percent	Average output, MWE
1/16/79	505	118	79.2	51
1/17/79	506	109	80.3	51
1/18/79	484	81.7	84.2	50
1/19/79	472	39.3	91.6	49
1/20/79	428	36.5	92.6	49
1/21/79	494	64.5	88.7	49
1/22/79	469	77.0	86.5	49
1/23/79	482	57.9	88.5	50
1/24/79	433	40.7	91.1	72[a]
1/25/79	522	48.7	90.9	94[a]
1/26/79	399	10.2	97.4	76[a]
1/27/79	404	9.0	97.7	90[a]
1/28/79	458	16.7	96.4	86[a]
1/29/79	480	45.1	90.8	91[a]
1/30/79	351	7.7	97.8	90[a]
1/31/79	395	10.1	97.7	91[a]
2/1/79	487	24.9	95.0	84[a]
2/2/79	466	21.6	95.4	75[a]
2/3/79	373	3.1	99.1	78[a]
2/4/79	386	3.1	99.2	85[a]
2/5/79	INLET PUMP COUPLING BROKEN			97[a]
2/6/79	PLANT SOUTH SCRUBBER DOWN			58
2/7/79	PLANT SOUTH SCRUBBER DOWN			58
2/8/79	PLANT SOUTH SCRUBBER DOWN			56
2/9/79	388	12.0	97.8	84[a]
2/10/79	389	9.3	97.6	88[a]
2/11/79	461	22.1	95.2	82[a]
2/12/79	455	10.3	96.8	81[a]
2/13/79	540	22.2	95.9	86[a]
2/14/79	OUTLET PUMP FAILURE			81[a]
2/15/79	INLET PUMP SYSTEM PLUGGING HOURLY			88[a]
2/16/79	INLET PUMP AND SHORT HEATER LINES REPAIRED			85[a]
2/17/79	451	29.1	93.7	94[a]
2/18/79	457	7.6	98.3	88[a]
2/19/79	461	7.5	98.4	79[a]
2/20/79	438	16.2	96.5	66[a]
2/21/79	493	26.0	94.7	68[a]

[a] Indicates both scrubber modules are operational. Approximately half of the boiler effluent is passed through each scrubber.

Table VIII. Frequency distribution of the data.

Percentage removal efficiency	Frequency (No. out of 30)	Percentage of time $\frac{\text{frequency}}{30 \text{ days}} \times 100$	Cumulative percentage $\frac{\Sigma \text{ frequency}}{30 \text{ days}} \times 100$
98–100	4	13.3	13.3
96–98	9	30.0	43.3
94–96	5	16.7	60.0
92–94	2	6.7	66.7
90–92	4	13.3	80.0
88–90	2	6.7	86.7
86–88	1	3.3	90.0
84–86	1	3.3	93.3
82–84	0	0	93.3
80–82	1	3.3	96.7
78–80	1	3.3	100
0–78	0	0	100

Mean percent efficiency = 93.5
Standard deviation = 5.4
Median percent efficiency = 95.3
Number of days >85% removal efficiency = 27
Number of days <85 and >75% = 3
Minimum = 79.2%
Maximum = 99.2%

2. U.S. Environmental Protection Agency, *Federal Register* **40** (182): 42178–42184 (Sept. 19, 1978).
3. U.S. Environmental Protection Agency, *Federal Register* **44,** (113): 33580–33624 (June 11, 1979).
4. K. Green and J. Martin, "Conversion of the Lawrence No. 4 FGD System," In *Proceedings: Symposium on Flue Gas Desulfurization,* Hollywood, FL, November 1977 (Volume I), EPA-600/7-78-058a (NTIS PB 282090), March 1978. pp. 255–276.

Mr. Peduto is Supervisor, Continuous Monitoring, GCA Corporation, GCA/Technology Division, Bedford, MA 01730. Mr. Strong is an electronics engineer, Research Triangle Institute, Research Triangle Park, NC. Mr. Kuykendal is Project Officer, U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory, Research Triangle Park, NC.